The interbreeding of sheep and goats

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Abstract — To determine the outcome of interbreeding sheep and goats, ewes and does were bred to rams and bucks, and their embryos recovered. Pregnancy was monitored in 2 does bred to a ram. Fertilization rates in ram × does, buck × does, ram × ewes, and buck × ewes were 72%, 96%, 90%, and 0%, respectively. Ram × doe fetuses died at 5 to 10 weeks.

Résumé — Reproduction interspécifique des moutons et des chèvres. Afin de déterminer le produit de la reproduction interspécifique des moutons et des chèvres, des brebis et des chèvres ont été accouplées à des béliers et des boucs et leurs embryons ont été récupérés. La gestation a été suivie chez deux chèvres accouplées à un bélier. Les taux de fertilisation chez les béliers × chèvres, boucs × chèvres, béliers × brebis et boucs × brebis furent respectivement de 72 %, 96 %, 90 %, et 0 %. Les fœtus béliers × chèvres sont morts entre 5 et 10 semaines.

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It is a relatively common practice to house or rear sheep and goats together. Under such conditions, they will readily interbreed, although documentation of the outcome of such interspecies matings is relatively sparse. In 1949, Warwick and Berry (1) reported that many female goats mated to rams became pregnant, but the embryos died before the end of gestation. Cytogenetic incompatibility was postulated as one of the causes of embryo death. Hancock and McGovern (2) similarly reported high fertilization rates followed by fetal loss between days 40 and 60 of gestation. McGovern (3) reported that does twice impregnated by rams lost their pregnancies earlier during the subsequent hybrid conception than following the first. Death of the hybrid fetus was attributed to hemolytic disease resulting from maternal antibodies developing against fetal red blood cells.

Roth *et al* (4) showed that sheep-goat hybrid embryos are capable of developing to term following embryo manipulation. When the hybrid inner cell mass (future embryo proper) was reconstructed within a sheep trophoblast (future placenta) and transferred to sheep recipients live hybrids were born, confirming that hybrids, under the right circumstances, are capable of full term development. Bunch *et al* (5) reported the "spontaneous" occurrence of live hybrid offspring resulting from the indiscriminate crossbreeding of a "Spanish" goat and a Barbados ram. Cribiu *et al* (6) and Pinheiro *et al* (7) also reported cases of sheep-goat hybrids, although the breeds were not reported. Attempts to create sheep-goat hybrids by planned matings have failed.

The reciprocal cross, ewes mated with bucks, is less well documented. Warwick and Berry (1) stated that the cross between ewes and bucks is invariably sterile. Bowerman and Hancock (8) reported 1 cleaved ovum among 40 collected from 15 ewes bred to bucks. However, neither account gave details of breeding, and subsequent studies have not been reported.

The present study, consisting of 2 experiments, was undertaken to examine the outcome of crossbreeding sheep and goats, particularly the less documented ewe-buck combination. In the 1st experiment, superovulated ewes and does were mated to mature, fertile, rams or bucks, and the reproductive tracts were flushed 1 to 4 d later to determine rates of fertilization for each cross. In the 2nd experiment, does were mated with a mature fertile ram and the resulting pregnancies were monitored using ultrasound. The hybrid fetuses were recovered and the does were rebred to the same ram.

Twenty Arcott ewes and 12 crossbred does were synchronized for estrus, superovulated, and bred to determine the rate of fertilization. Estrous synchronization and superovulation were accomplished by 1 of 2 protocols, as follows. Animals destined for surgical embryo recovery were treated with 60 mg medroxyprogesterone acetate vaginal pessaries (Veramix, Tuco Products, Division of Upjohn, Orangeville, Ontario) placed for 14 d. Beginning on day 12 after insertion of the pessary, a total dose of 20 mg follicle-stimulating hormone (FSH-p, Schering Canada, Pointe Claire, Quebec) was injected, IM, at 12-hour intervals on 3 consecutive days (5, 4, 4, 3, 2, 2 mg). Animals destined for postslaughter embryo recovery were given 3 IM injections of 50 mg progesterone in an alcohol water base (Centra Progestin, Central Sales, Brampton, Ontario) every 4th d, followed by 4 daily IM injections of 10 mg progesterone in a sesame oil base (Gesterol in Oil, Sertis Laboratories, Phoenix, Ariozona, USA). At the time of the 3rd 10-mg injection, the FHS-p regimen (see above) was initiated. Ewes

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Table 1. Summary of embryo/ova collections 1–4 d after observed estrous in ewes and does bred to rams or bucks

	Type of cross (female species × male species)			
	sheep × sheep	sheep × goat	goat × goat	goat × sheep
Females	6	14[a]	8	4
Corpora lutea	92	>150[b]	85	81
Embryos/ova recovered	77	146	79	75
Embryos	69	0	76	54
Unfertilized ova	8	139	1	20
Fragmented ova	0	7	2	1
% Fertilized	89.6	0.0[c]	96.2	72.0

[a]Includes the 5 ewes that were inseminated laparoscopically
[b]Accurate counts of CL's not available for some ewes
[c]Significantly different, ($P < 0.05$) from all other groups

treated with either protocol began to exhibit estrous behavior within 24 h of the final FSH-p injection. Upon initiation of estrus, ewes and does were penned with rams (Arcott or Suffolk) or bucks (Nubian or Nubian cross) for at least 24 h. Breeding by rams was confirmed by using a marking harness. Breeding by bucks was confirmed by vaginal swabbing the ewes within 24 h of exposure. Five of the ewes were inseminated with buck semen by intrauterine laparoscopic insemination, as described by Killeen (9). The oviducts were flushed surgically or postmortem with phosphate buffered saline plus 2% fetal calf serum. Embryos/ova were located using a stereomicroscope and classified as fertilized or unfertilized. A chi-squared test was used to compare mean fertilization rates. The results are summarized in Table 1.

High fertilization rates were obtained from ram-bred ewes (90%) and buck-bred does (96%). Similarly, the fertilization rate among ram-bred does was also high (72%). None of the ova collected from ewes inseminated with buck semen or mated to bucks showed signs of fertilization. Even laparoscopic insemination of buck semen into the uterus of 5 superovulated ewes did not lead to fertilization. Seven of the ova collected from 1 buck-bred ewe were fragmented and showed signs of degeneration.

In the 2nd part of the study, a Toggenburg and a Lamancha doe had estrus synchronized and were naturally bred to a Suffolk ram. Does were monitored for pregnancy by ultrasound, per rectum, using a B mode 5 mHz linear array real time rectal probe without extensions. Beginning on day 24 postbreeding, the 2 does identified as pregnant were examined daily from day 30 until a fetal heart beat could no longer be detected. Fetuses were recovered by hysterectomy or cloprostenol injection within 48 h of the last detected heart beat. The fetal heart beat was no longer detectable in the Toggenburg on day 46 of gestation. The recovered fetus had a crown-rump length of 5.9 cm and no apparent malformations. In the Toggenburg's 2nd hybrid pregnancy, which contained several fetuses, fetal deaths occurred over several days but were complete by day 36 of gestation. One intact fetus was recovered and had a crown-rump length of 2.1 cm. The 1st hybrid pregnancy in the Lamancha consisted of a single fetus which showed a heart beat until day 69. When recovered, it measured 7.6 cm with no apparent malformations. In the 2nd hybrid pregnancy, this animal was given cloprostenol on the 34th day of gestation and the 2.4 cm hybrid fetus was recovered 2 d later. During this pregnancy, there appeared to be a greater amount of allantoic fluid present than was observed in the animal's 1st hybrid pregnancy. Development of each hybrid fetus appeared to progress normally; however, placental development appeared to be abnormal. The placentomes were much smaller and their shape was flatter and more discoid than that of comparatively aged ovine or caprine placentomes, which are concave. Jones and Fecteau (10) reported a case of hydrops uteri in an Alpine doe pasture bred by a Barbados ram, in which ultrasound examination revealed placentomes to be small, flat, and relatively scarce. Secondary complications, including tachypnea, tachycardia, and hind limb paresis, were also noted. Parturition was induced and the doe recovered. A similar disproportionate accumulation of fetal fluids, hydramnios, has also been reported in cattle × bison hybrids (11).

The high fertilization and pregnancy rates and subsequent fetal loss in does mated to rams is consistent with previous reports. While, in the present study, hybrid pregnancies were terminated after fetal death and not allowed to run their natural course, loss in productivity and reproductive efficiency was to be anticipated. It is not known when the does would have cycled after loss of the fetus. Effects, if any, on the success of subsequent breedings are also unknown.

A case of a Nubian doe bred by a Barbados ram was monitored by Henderson and Robertson (personal communication). These 2 animals were housed together and were observed mating. The doe had no contact with a buck but was confirmed pregnant. Eighty days later, a fetus was naturally expelled and a 2nd fetus was expelled the following day. The doe continued to discharge for a 1-week period and was given antibiotics during this time. The doe returned to estrus and was rebred to a buck 6 wk later, but no pregnancy resulted. During the following fall breeding season, the doe was mated to a buck and gave birth to a normal doe kid.

In light of the high fertilization and pregnancy rates in the doe-ram crosses, the total lack of fertilization in the ewe-buck crosses was surprising. Polarity in the success or failure in interspecies crosses has been identified in several species. However, with the exception of

the ferret × mink cross, polarity in reciprocal crosses in other species is usually manifest as differences in the rate of fertilization rather than as an inability to fertilize. Ongoing studies in our laboratory have, however, shown that, under in vitro conditions, both combinations of sheep and goat crosses are possible and occur with similar rates of fertilization, and both produce similar rates of pregnancy (12). This confirms the ability of the gametes to successfully interact and suggests that the barrier to fertilization in vivo is at the level of sperm transport or capacitation. By-passing the cervix by inseminating directly into the uterus did not promote fertilization, suggesting that the capacitation of buck spermatozoa in the reproductive tract of the ewe may be disadvantaged.

Our observations provide documentation of the failure of goat sperm to fertilize sheep ova in vivo and provide new information on the outcome of indiscriminate breeding of sheep and goats. The economic implications in terms of reproductive inefficiency and failure are greatest in the case of does mated to rams. Not only is the risk of a missed breeding season increased, but there are heightened risks for complications, such as, hydrops, fetal mummification, and uterine infections. Depending on the particular month of breeding, it is quite likely that an entire breeding season could be lost. CVJ

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Answers to Quiz Corner / Les réponses du Test Éclair

1. a
2. d
3. a
4. a — Chronic subclinical indigestion is often associated with laminitis in ruminants.
   a — L'indigestion chronique subclinique est souvent associée à la fourbure chez les ruminants.
5. a — Cats ingest *Toxoplasma* cysts in muscles (raw meat) of rodents and meat-producing animals.
   a — Les chats ingèrent des kystes de Toxoplasma *provenant des muscles (viande crue) de rongeurs et d'animaux de consommation.*
6. d
7. b — Increased dentin narrows the pulp cavity. Older animals have loss of definition of the lamina dura.
   b — L'épaississement de la dentine rétrécit la cavité pulpaire. Les animaux plus âgés ont une perte de définition de la lamina dura.
8. d
9. c
10. b — Twins are the most likely reason for finding more than 2 limbs in the birth canal during a bovine dystocia. Though more that 2 limbs may be present within the birth canal with schistosomus reflexus, these are much rarer occurrences than twins. Transverse presentations are extremely rare. Calves with perosomus elumbus are usually single. Calves with amorphus globosus do not have limbs.
    b — La présence de jumeaux est la raison la plus probable de retrouver plus de deux membres dans le vagin lors de dystocie chez les bovins. Bien que plus de deux membres puissent être présents dans le vagin chez un veau schistosomus reflexus, cette condition est beaucoup plus rare que la présence de jumeaux. Les présentations transverses sont extrêmement rares. Il y a habituellement un seul veau perosomus elumbus. Les veaux qui ont une malformation d'amorphus globosus n'ont pas de membres.